Combustible Dust Booklet

Introduction

In general, over 70% of organic dusts are explosible if given an adequate ignition source and appropriate dust/air concentration. Unless the material is combustible and finely divided (generally less than 420 microns/40 mesh) it cannot sustain flame propagation in a suspended dust/air atmosphere. The earliest explosions involving industries handling powder materials, like the coal industry and flour mills, were attributed to a flammable gas, which was thought to be produced by the dispersed dust. It was not until the latter part of the nineteenth century that it was realized that coal dust could ignite and explode in the absence of a flammable gas, or that flour dust alone was responsible for the increasing number of explosions in mills. Recent statistics from the USA and some European countries indicate that dust fires and explosions are not uncommon in industries handling or processing bulk solids and powders. So which industries are at risk? Materials in powder form are used in a wide variety of industries, including pharmaceutical, chemical, plastics and food, among others. Many powders handled by these industries will explode if dispersed in the presence of an ignition source. The purpose of this booklet is to provide necessary information to Colorcon customers regarding our products.

Dust Fire or Explosion Hazards

A chemical dust deflagration occurs when the right concentration of finely divided chemical dust suspended in air is exposed to a sufficient source of ignition to cause ignition (combustion) of the dust. If the deflagration is in a confined area, an explosion potential exists. These materials can also cause other fires. Combustible dust is often either organic or metal dust that is finely ground into very small particles. The actual quantity of dust that may accumulate in an affected area may vary, depending upon air movement, particle size, or any number of other factors.[1]

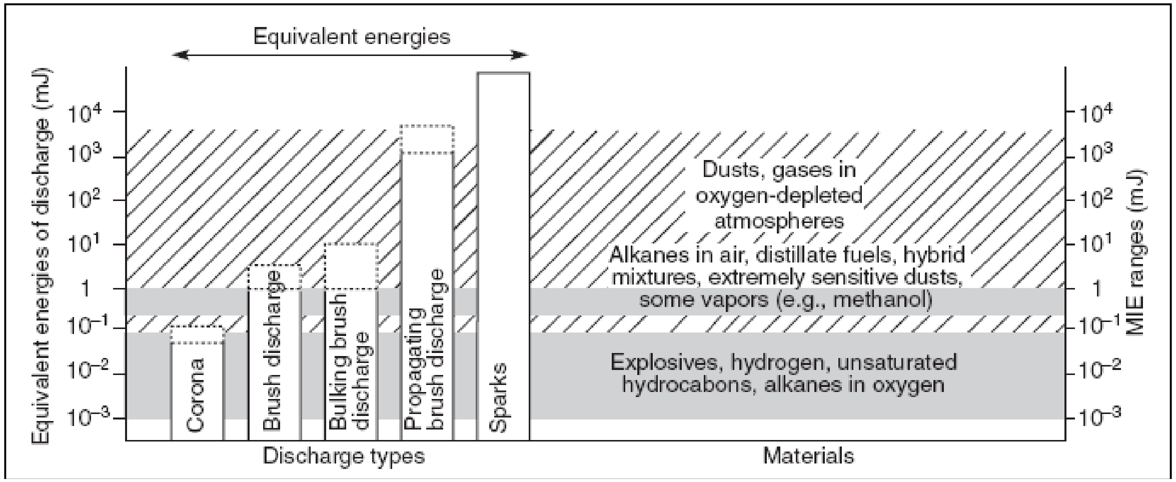
[1] From OSHA Combustible Dust National Emphasis Program, CPL 03-00-008

Dust Hazard Properties

Minimum Dust Cloud Ignition Energy or Powder Minimum Ignition Energy (MIE)

This value is a measure of the ease of ignition of a suspended dust cloud by low energy ignition sources, such as electrostatic sparks. Materials that have low MIE values are more likely to ignite from low energy electrostatic ignition sources. Such ignition sources include electrostatic charges created when electrically resistant powders are transferred through equipment and the charges built up on personnel. MIEs less than 100 mJ are considered to represent a hazard of ignition from weak electrostatic sources. The charge generated on personnel is of the order of 20-30 mJ.

Figure 1 Significance of Minimum Ignition Energy[2]



For materials having a MIE of less than 1,000 mJ, and a Minimum Ignition Temperature <500°C, there is a possibility of ignition by sparks caused by friction/impact of steel objects.

[2] From NFPA 77, FIGURE 5.3.1 Approximate Energies of Types of Discharges Compared with Minimum Ignition Energies (MIEs) of Typical Combustible Materials. *(Adapted from H. L. Walmsley, Avoidance of Electrostatic Hazards in the Petroleum Industry, p. 26.)*

Minimum Dust Layer Ignition Temperature, MIT_{layer} or LIT (°C)

This temperature is the point at which a deposited dust layer will ignite if exposed to a hot surface. Typical values for organic dusts are 300 to 450 °C. This property is used when specifying the maximum surface temperature for devices and equipment surfaces, such as hot air dryers, that could be exposed to an ignitable dust layer and in the specification of electrical device surface temperatures for use in hazardous locations.

Minimum Explosible Concentration (MEC)

The minimum explosible concentration (MEC) is the minimum concentration of dispersed dust capable of being ignited **and** supporting flame propagation. MEC data can be used to specify ventilation and extraction as a means of dust explosion prevention. NFPA 69[3] recommends that when control of the flammable atmosphere is used as a basis of safety, ventilation should be sufficient to maintain the average fuel concentration to less than 25 percent of the lower flammable limit (LFL). Thus, ventilation should be sufficient to limit the average concentration of dispersed dust to less than 25 percent of the MEC, since the MEC can be thought of as the LFL for an explosible dust. Typical MECs for many combustible dusts lie in the 20 to 120 gm/m^3 range. The use of ventilation is generally not recommended as a sole basis of safety for an operation; however, since the evolution of localized dust concentrations exceeding the MEC may be inevitable even when adequate ventilation is provided.

Maximum Pressure, P_{MAX}

This is the maximum closed system pressure caused by a confined fuel(dust)/air explosion. Typical deflagration explosions such as dust/air explosions will produce closed system pressures of about 8 to 10 barg (116 to 145 psig). This property can be used to specify containment design criteria for new equipment as a basis of safety.

[3] NFPA 69 – Standard on Explosion Prevention Systems; National Fire Protection Association (NFPA);

Dust Explosion Class and Deflagration Index, K_{St}

One aspect of explosion risk of dusts is the level of consequence of an uncontrolled confined explosion. The Deflagration Index, K_{St} is calculated from the maximum rate of pressure rise and the size of the test sphere**.** This property is a scaling factor used to predict confined explosion behavior in different size enclosures based on a fixed test enclosure, usually 20-liters in accordance with ASTM E-1226. This index has application in the design of explosion protection systems such as vents or suppression systems and is an indicator of the level of hazard presented by the material. Dusts are classified based on the value of the Deflagration Index, as described in the next paragraph. Four classes of dust explosion hazard are used for rating dusts, ST-0, ST-1, ST-2 and ST-3. A range of deflagration index values as shown below defines each class.

Dust Hazard Classes

Hazard Class	Deflagration Index, K_{ST} Range Bar-m/sec	Descriptive Phrase
ST-0	0	No Explosion
ST-1	Less Than 200	Weak Explosion
ST-2	200-300	Strong Explosion
ST-3	Greater Than 300	Very Strong Explosion

Explosible dusts with K_{ST} values below 200 bar-m/sec are classified as ST-1 dusts (weak explosive dusts). This type of material, should ignition occur in a confined space, will produce a relatively weak explosion. Even a weak explosion can have extreme consequences and should not be taken lightly. Most dust handling equipment is not designed to survive dust explosion pressures and will fail catastrophically if exposed.

Properties of Colorcon Product Lines

1. Materials on the following chart are combustible particulate solids and could explode if suspended in air in an adequate concentration and subjected to an adequate ignition source. Such events can cause significant equipment and building over-pressurization leading to damage and threat to life. Handling of this material requires special precautions.

Product Family	Explosion Class A=explosible, B=not explosible	St Class	Pmax (bar g)	Kst (bar* m/s)	Minimum ignition energy MIE (mJ)	Minimum ignition Temperature of a dust cloud, MIT (deg C)	Minimum ignition Temperature of a dust layer, LIT (deg C)
Acryl-EZE®	A	1		as high as 200	as low as 100	as low as 480	as low as 275
D&C Red #7/Lithiol Rubin CL 47%-53%	A	2	as high as 8.2	as high as 201	as low as 100		
25/30 Sugar Spheres	A	1	as high as 8.0	as high as 170	as low as 10		as low as 400
Starch 1500® Starcap®	A	1	as high as 7.5	as high as 145	as low as 500		as low as 400
Opadry®	A	1	as high as 9.0	as high as 200	as low as 100	as low as 360	as low as 275
Opadry® Enteric	A	1		as high as 200	as low as 10	as low as 420	as low as 275
Opadry® II	A	1	as high as 6.0	as high as 50	as low as 100	as low as 360	as low as 150
Opadry® NS	A	1	as high as 7.0	as high as 200	as low as 500	as low as 380	as low as 270
Opalux®	A	1	as high as 7.0	as high as 100			
Opalux® Dry	A	1	as high as 6.5	as high as 92	as low as 1000		as low as 400
Pigment Blend	A	1		as high as 200	as low as 100		as low as 275
FD&C Lake	B	0					
Phthalavin PVAP (Jet-Milled)	A	2	as high as 8.5	as high as 230	as low as 25		
Phthalavin PVAP	A	1	as high as 7.5	as high as 170	as low as 25	as low as 420	as low as 400
Rapid Subcoat	A	1	as high as 6.1	as high as 65	as low as 1000		as low as 400
POLYOX™	A	1		182	under 10		
METHOCEL™	A	1	8.9	88	as low as 29	360	
ETHOCEL™	A	1	8	as high as 200	as low as 3	380	
Sureteric®	A	2	as high as 7.5	as high as 220	as low as 10		as low as 400

Dust fire and explosion properties vary significantly from material to material and are strongly dependent on a powder's moisture content, particle size, and particle shape. The finest particles will exhibit greater ignition sensitivity and explosion violence when compared to larger ones. Also, the presence of flammable vapors or gases in a dust laden atmosphere can dramatically increase the severity and ignition sensitivity of a given atmosphere. This data represents only particular samples tested. This data may not represent the dust explosion hazards associated with fugitive dust deposits because particle size segregation often occurs as dusts are lofted onto elevated surfaces.

Please consult with OSHA regulations, applicable regional regulations, and National Fire Protection Association (NFPA) consensus codes and standards for the processing and handling of combustible particulate solids. Specific codes, standards, and reference sources considered are listed below:

1. NFPA 654 "Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids."
2. NFPA 61 "Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Processing Facilities"
3. NFPA 77 "Recommended Practice on Static Electricity"
4. NFPA 68 "Standard on Explosion Protection by Deflagration Venting"
5. NFPA 69 "Standard on Explosion Prevention Systems"
6. NFPA 70 "National Electrical Code"
7. NFPA 499 "Recommended Practice for the Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas."
8. DSEAR-Dangerous Substances and Explosive Atmospheres Regulations, UK
9. EU Directive 99/92/EC (ATEX 137 Directive)
10. OSHA Combustible Dust National Emphasis Program, CPL 03-00-008
11. Dust Explosions in the Process Industries, Rolf Eckhoff
12. Electrostatic Hazards in Powder Handling, Martin Glor

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